The Hunt For Dark Matter Conference Summary

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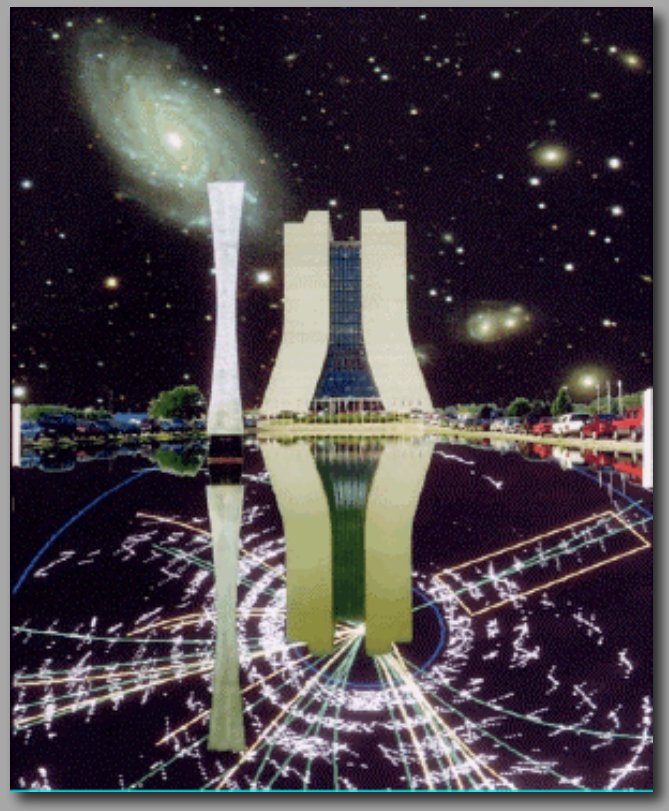

Fermilab
May 12, 2007

An Exciting Time For Dark Matter…
A New Kind of Dark Matter Meeting

~20 Excellent plenary talks (only a few others)

~60 Parallel talks - very wide range of topics, from particle physics theory to technical aspects of detector technology

~170-180 Participants!

Quasi-equal emphasis on direct, indirect and collider searches

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⇒ Makes writing a true summary talk a very difficult task

Hunting For Dark Matter

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The Field of Particle Dark Matter Candidates

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SUSY DM CANDIDATES

Spin	U(1) M_1	SU(2) M_2	Up-type μ	Down-type μ	$m_{\tilde{\nu}}$	$m_{3/2}$
2						G graviton
3/2		Neutralinos: $\{\chi \equiv \chi_1, \chi_2, \chi_3, \chi_4\}$				$\tilde{G}$ gravitino
1	B	W^0				
1/2	$\tilde{B}$ Bino	$\tilde{W}^0$ Wino	$\tilde{H}_u$ Higgsino	$\tilde{H}_d$ Higgsino	ν	
0			H_u	H_d	$\tilde{\nu}$ sneutrino	

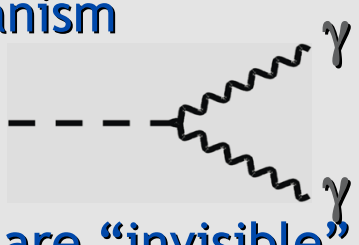
(Jonathan Feng's Talk)

Axions

CP conservation in QCD by Peccei-Quinn mechanism

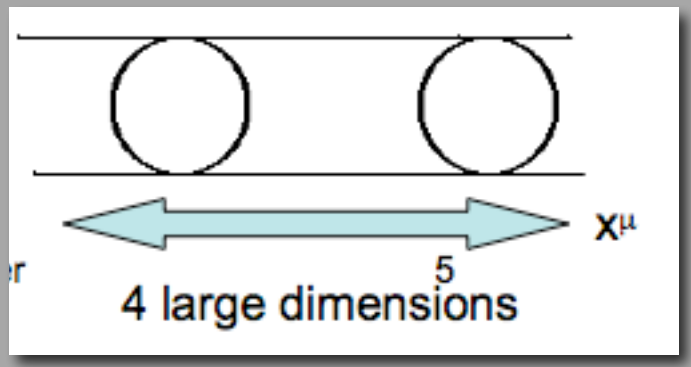
→ Axions $a \sim \pi^0$

$m_\pi f_\pi \approx m_a f_a$



For $f_a \gg f_\pi$ axions are "invisible" and very light

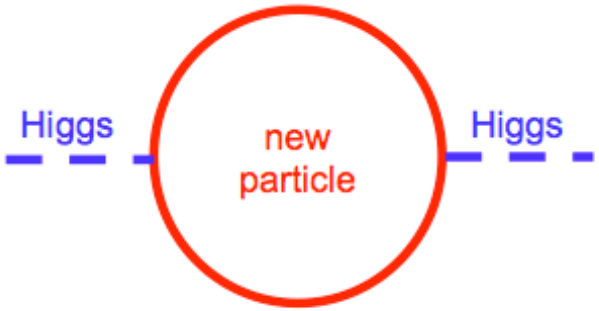
(Georg Raffelt's Talk)



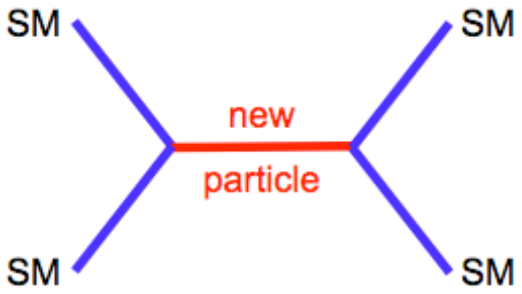
(Tim Tait's Talk)

LEP'S COSMOLOGICAL LEGACY

Gauge Hierarchy



Precision EW



- Simple solution: impose a discrete parity, so all interactions require pairs of new particles. This also makes the lightest new particle stable.

Cheng, Low (2003); Wudka (2003)

- LEP's Cosmological Legacy:

LEP constraints ↔ Discrete symmetry ↔ Stability

THE "WIMP MIRACLE"

(1) Assume a new (heavy) particle χ is initially in thermal equilibrium:

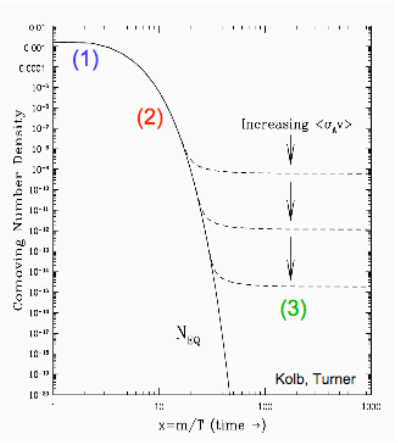
$\chi\chi \leftrightarrow \bar{f} f$

(2) Universe cools:

$\chi\chi \not\rightleftarrows \bar{f} f$

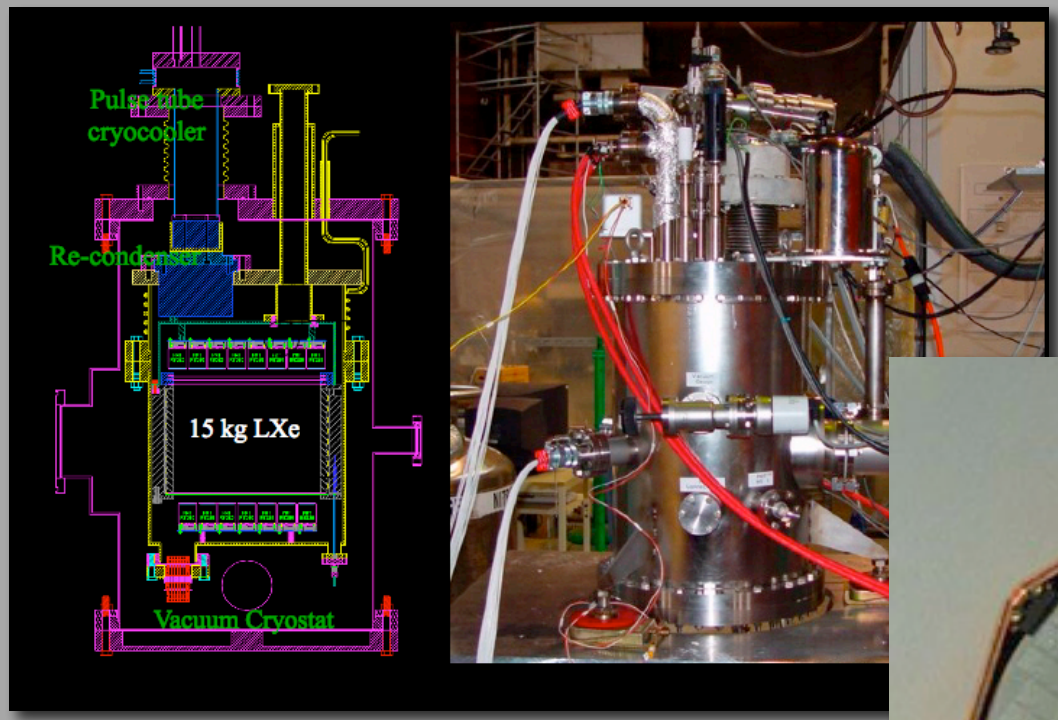
(3) χs "freeze out":

$\chi\chi \not\rightleftarrows f f$

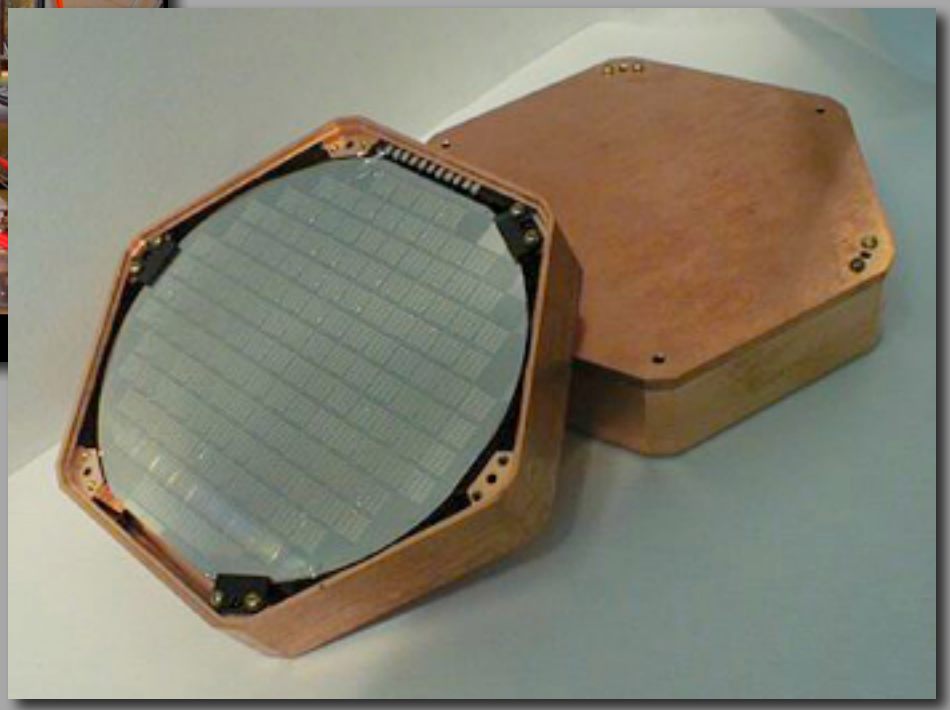


Direct Detection!!!

XENON 10



CDMS II

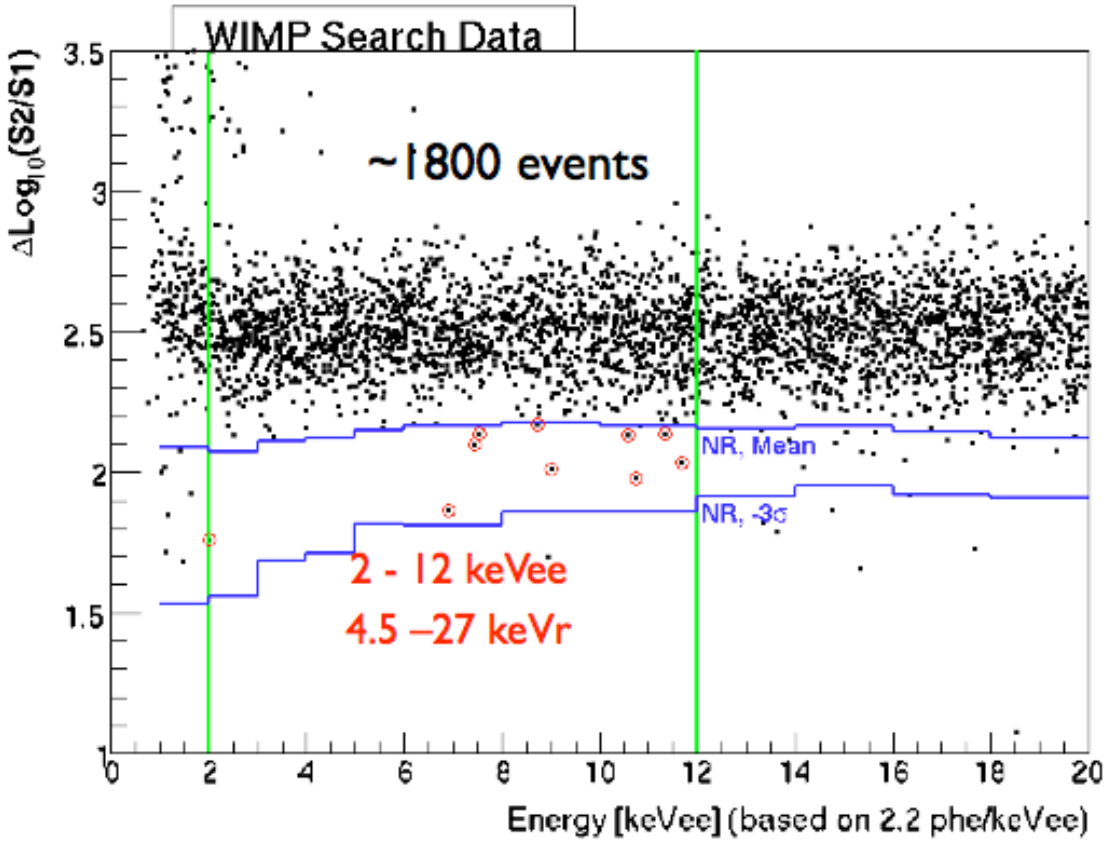


(See talks by D. McKinsey and S. Golwala)

Direct Detection!!!

XENON10 WIMP Search Data

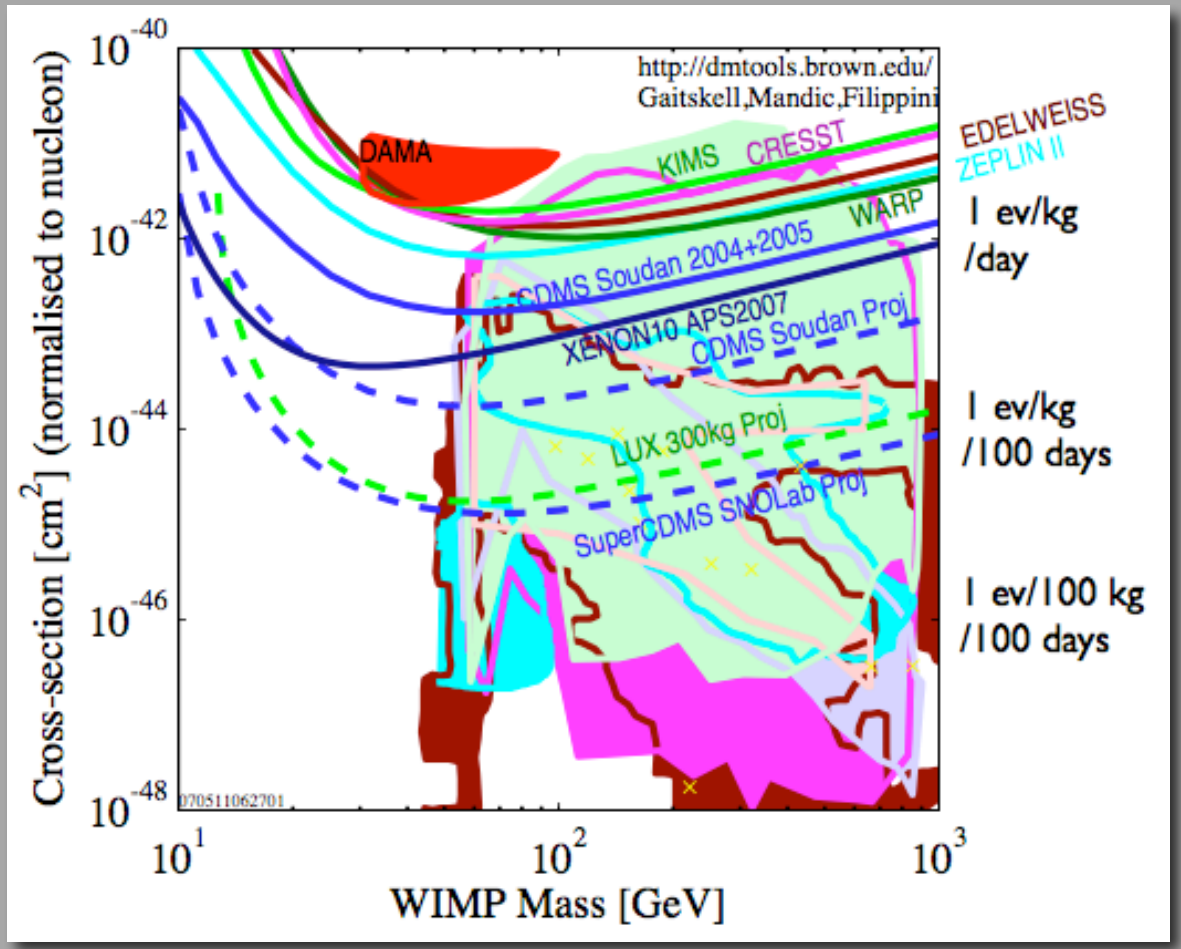
136 kg-days Exposure= 58.6 live days x 5.4 kg x 0.86 (ε) x 0.50 (50% NR)



- WIMP "Box" defined at ~50% acceptance of Nuclear Recoils (blue lines): [Mean, -3σ]
- 10 events in the "box" after all cuts in Primary Analysis
- 6.9 statistical leakage events expected from ER band
- NR energy scale based on 19% constant QF

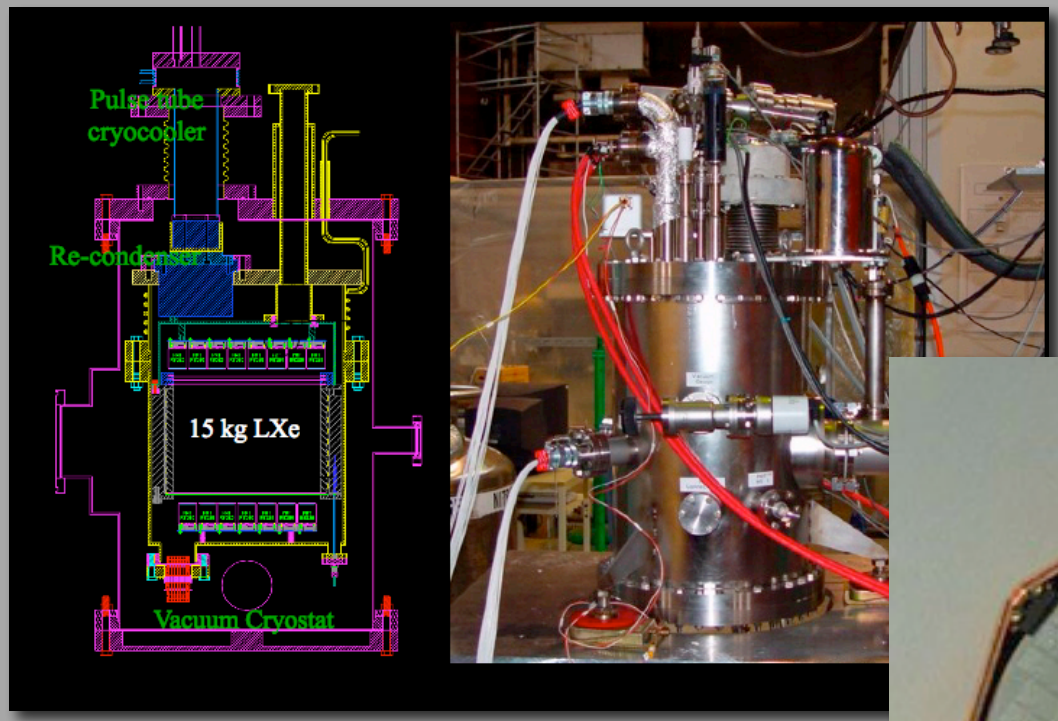
Direct Detection!!!

New XENON 10 Limit (April APS Meeting)

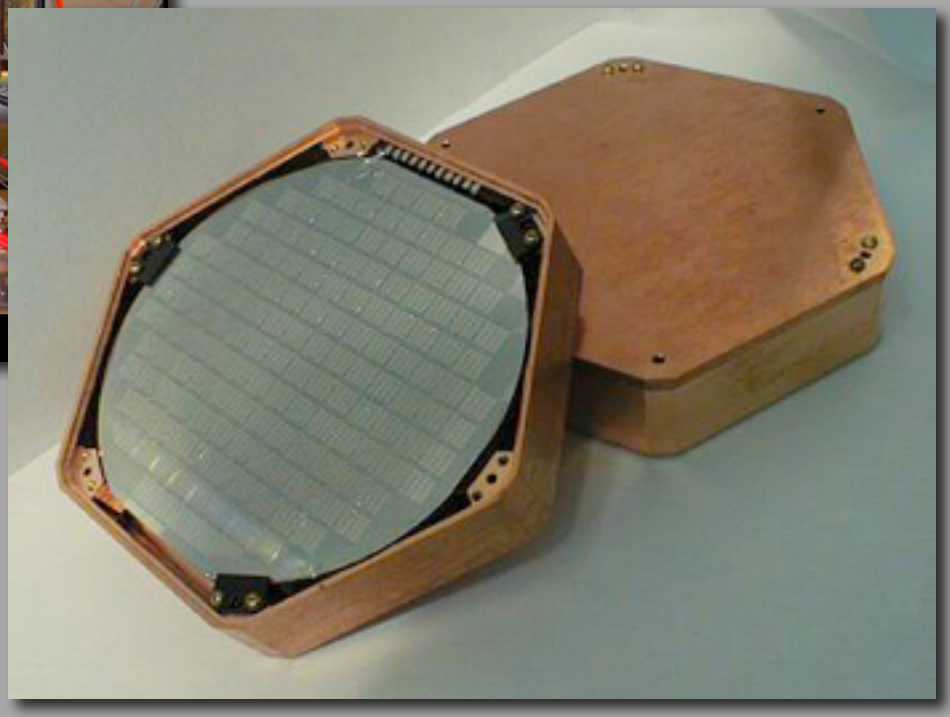


Direct Detection!!!

XENON 10

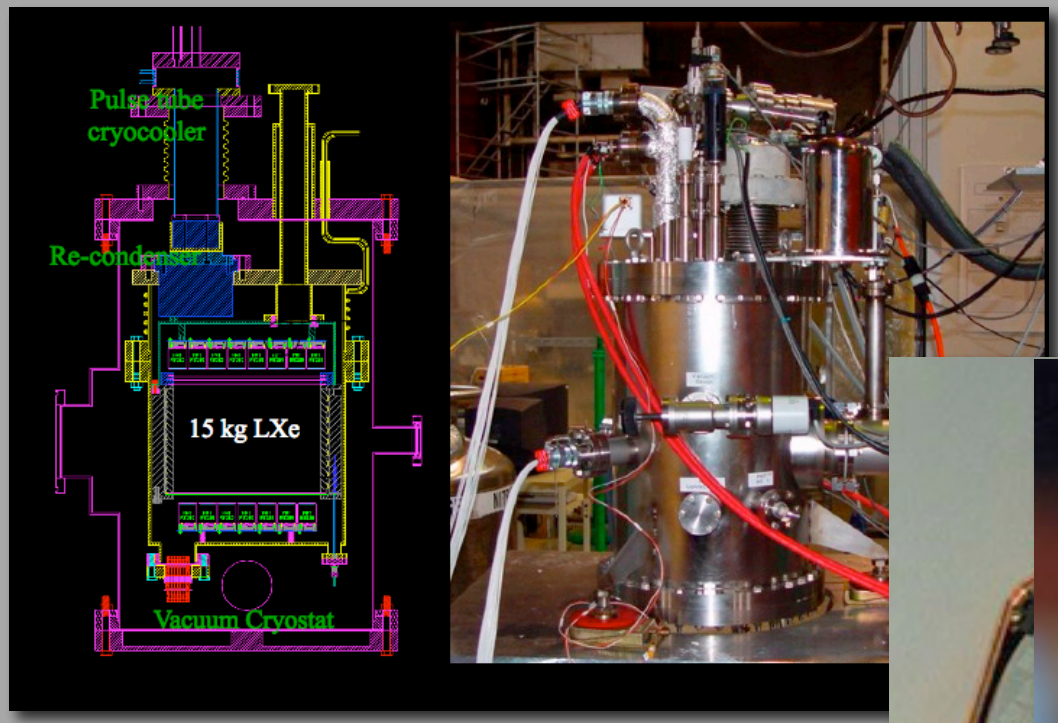


CDMS II



Direct Detection!!!

XENON 10



CDMS II

Direct Detection!!!

XENON 10

CDMS II

Direct Detection!!!

XENON 10

CDMS II

There Is No Telling Who Will Detect Dark Matter First

Direct Detection!!!

Many Other Experiments in the Running:
Zeplin III, LUX, WARP, XMASS,CLEAN, DEAP, …and a few dozen others

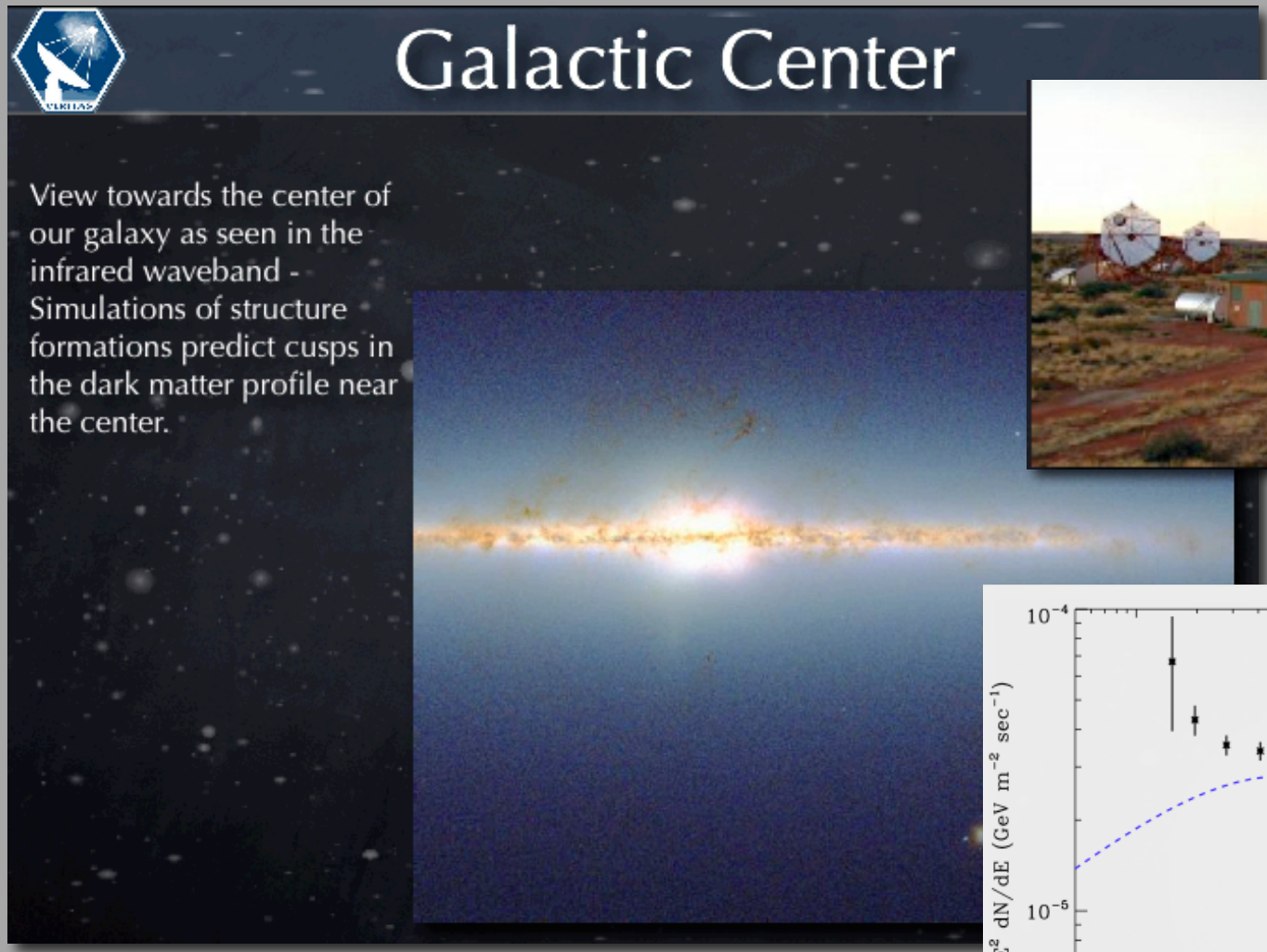
Indirect Detection

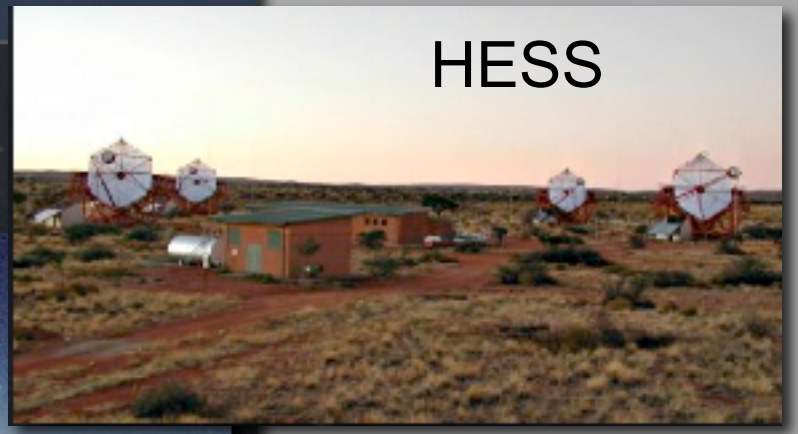
VERITAS, HESS and MAGIC in operation

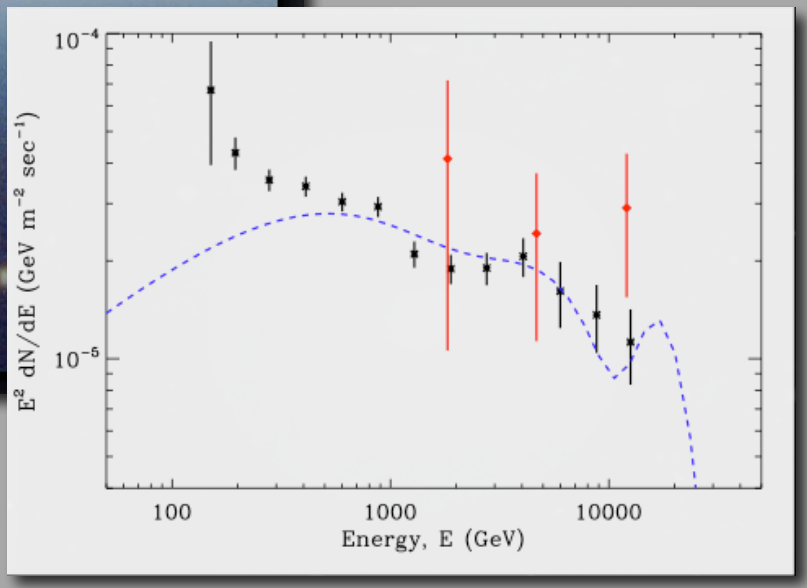
GLAST to launch late in 2007

(See Talk By Jim Buckley)

Indirect Detection



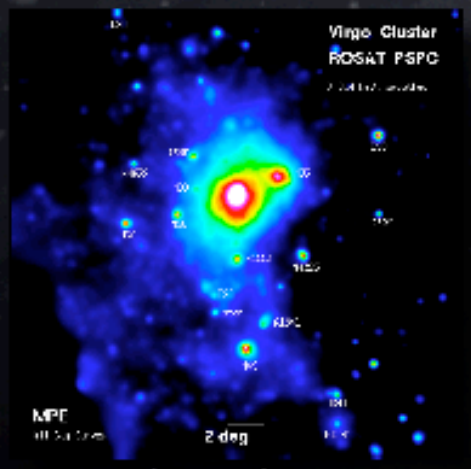




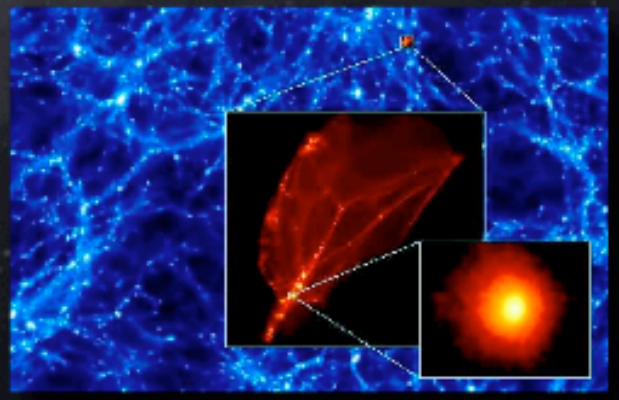
Dark Matter - Where Next?

Andromeda Galaxy

Dwarf Galaxies



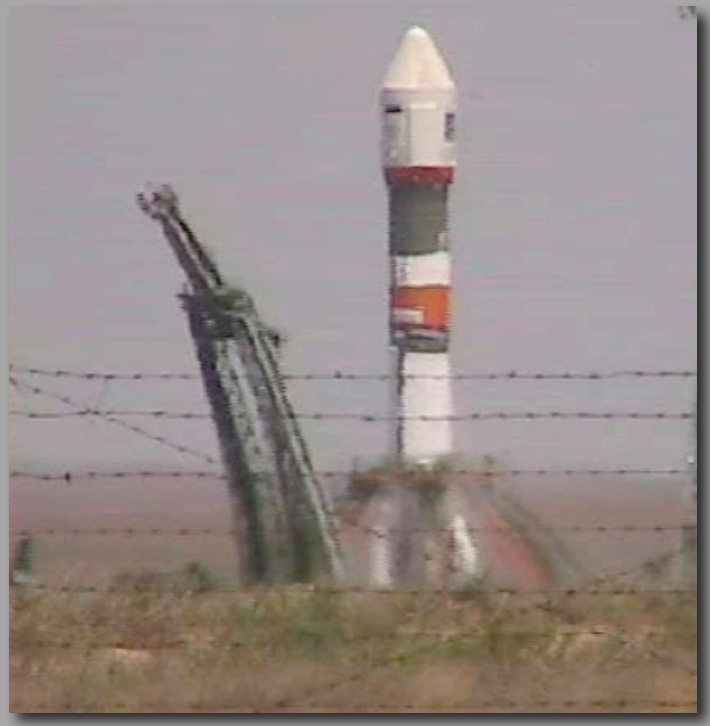
Virgo Galaxy Cluster (X-ray)

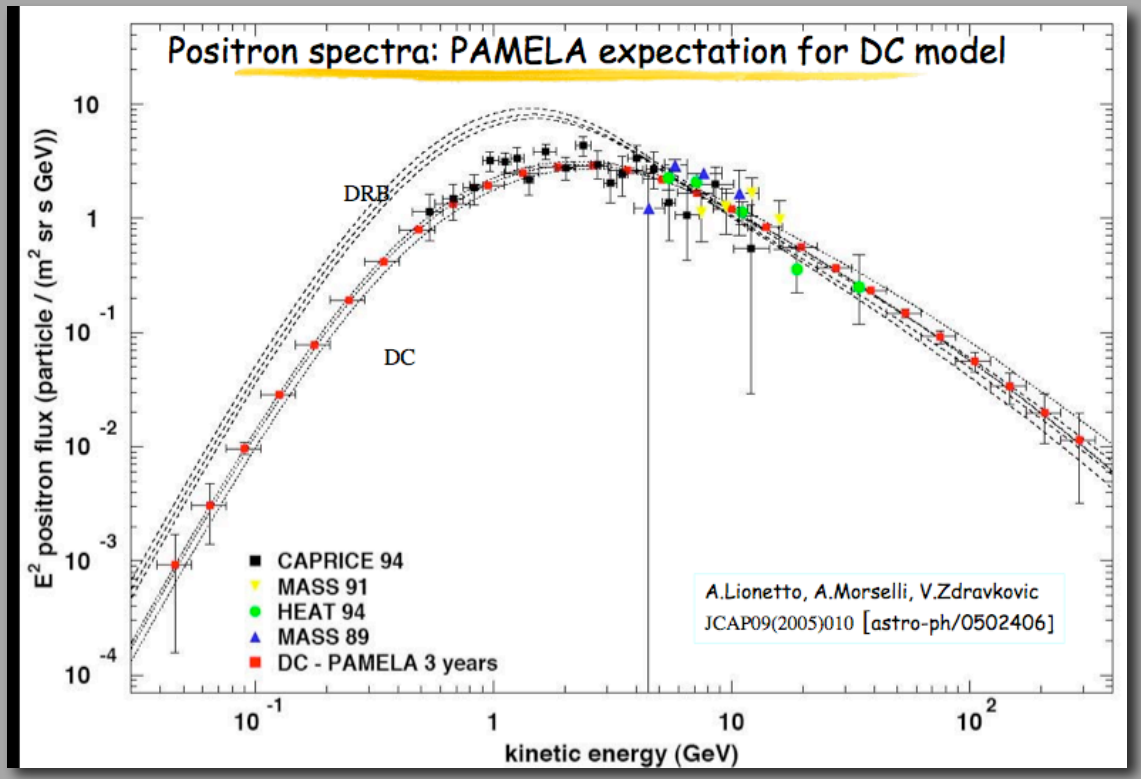


Galactic Minihalos

Indirect Detection

PAMELA's Launch- 480 million events!

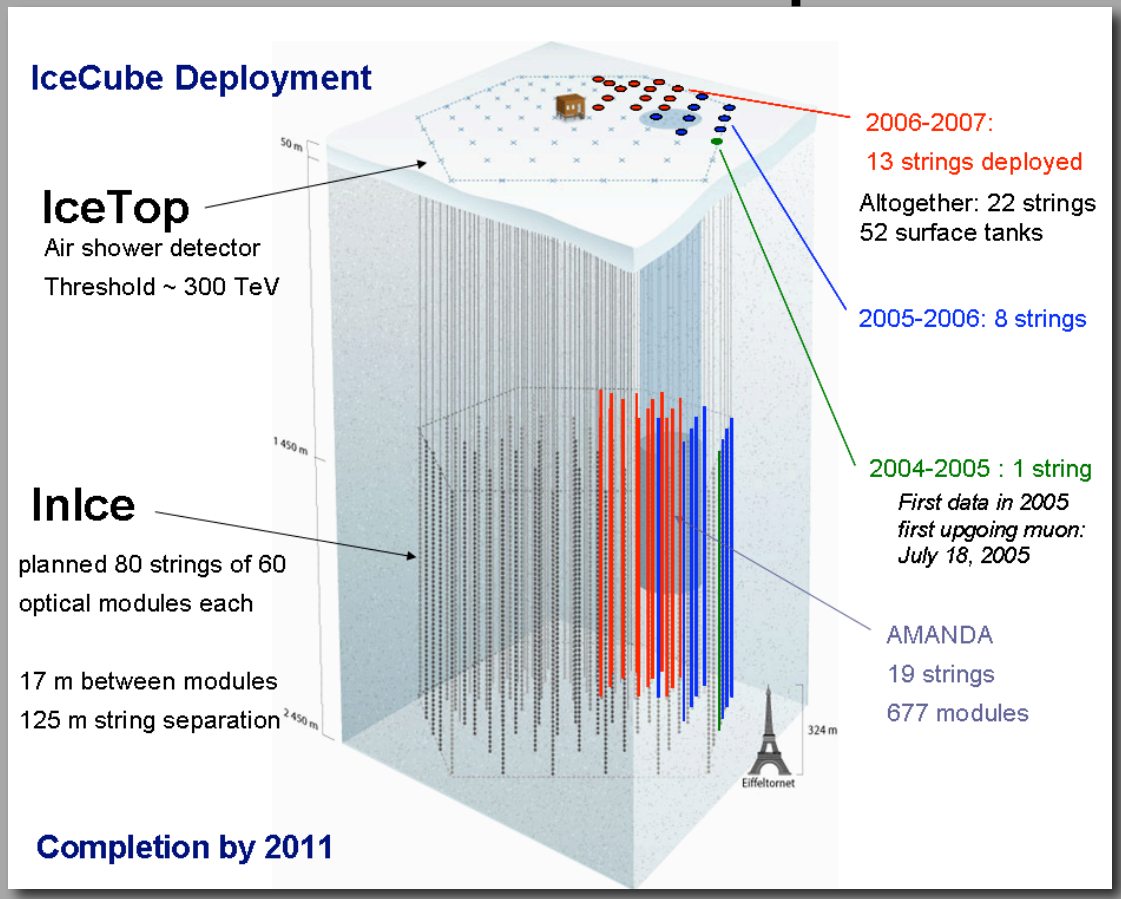


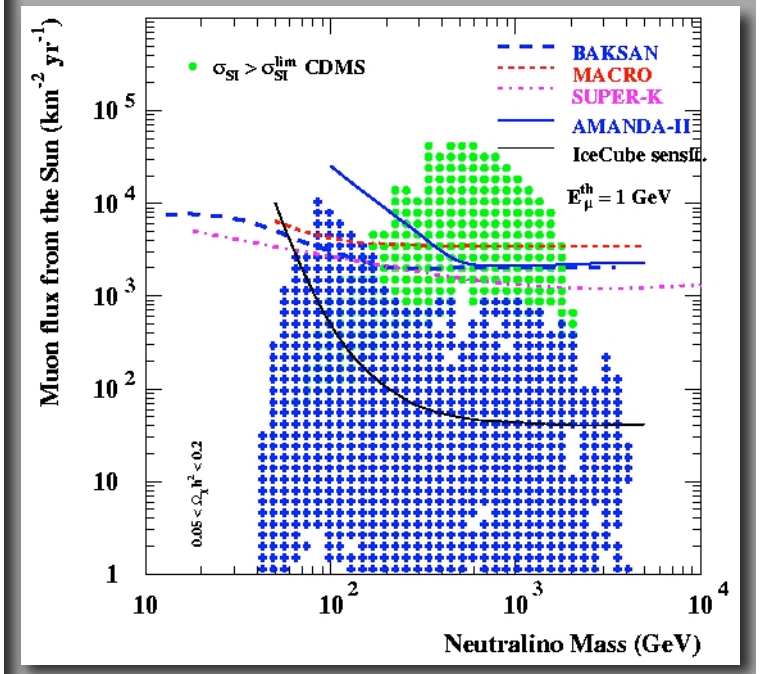


Will dramatically improve measurement of cosmic positron and antiproton spectra (See Aldo Morselli's Talk)

Indirect Detection

IceCube is 22/80 completed!





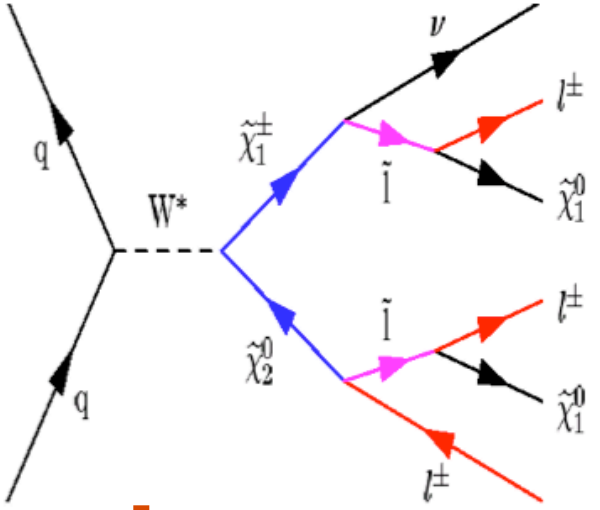
IceCube will test WIMPs with large spin-dependent scattering cross sections - complementarity to direct searches

(See Francis Halzen's Talk)

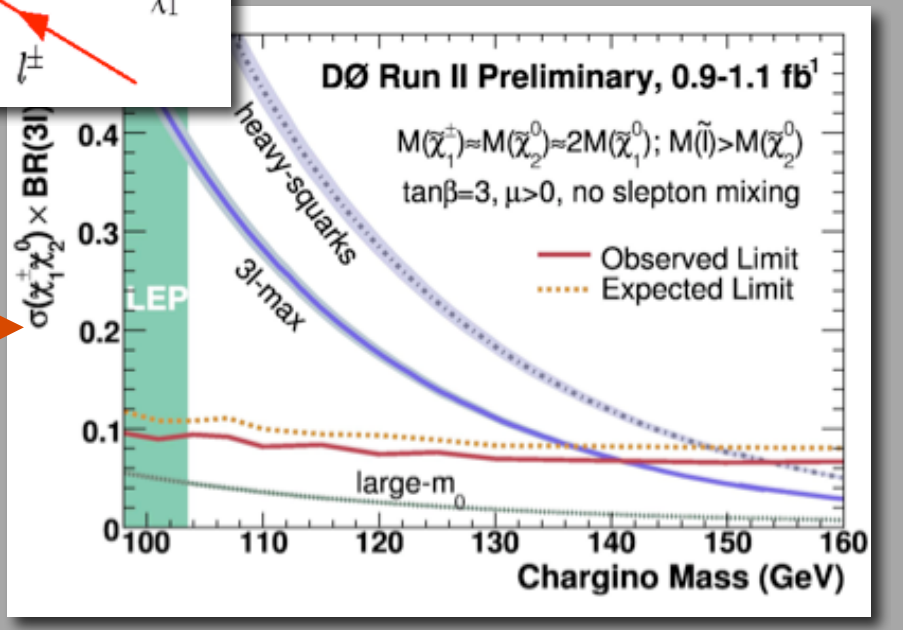
Colliders - The Tevatron

Search for Chargino-Neutralino Production

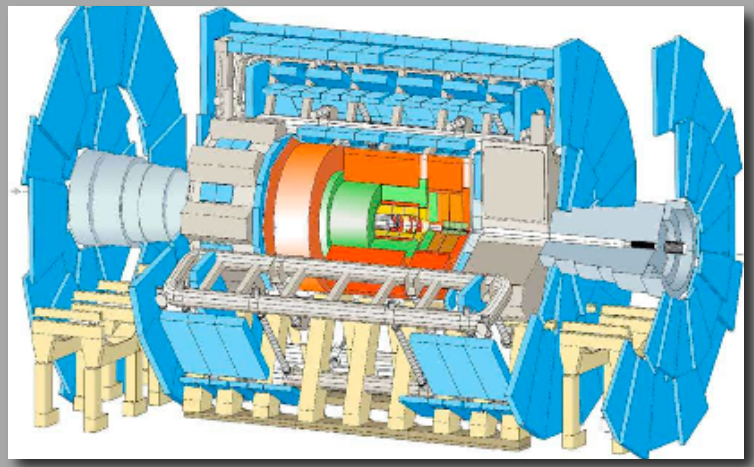
- Trileptons from chargino-neutralino: flagship analysis for discovery of SUSY at the Tevatron

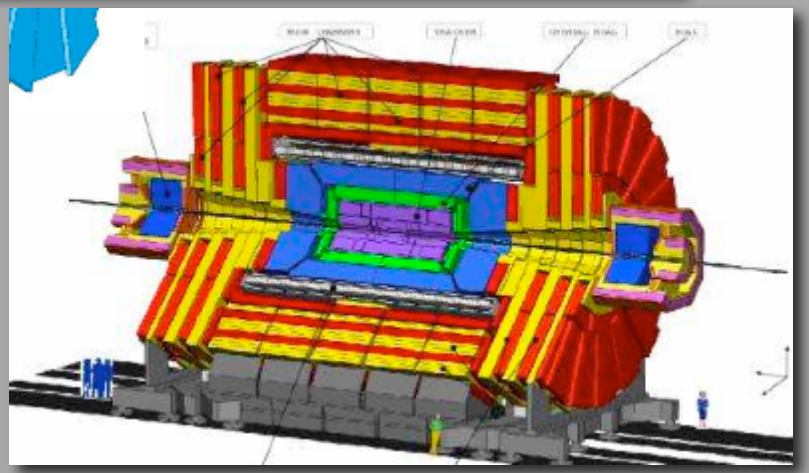


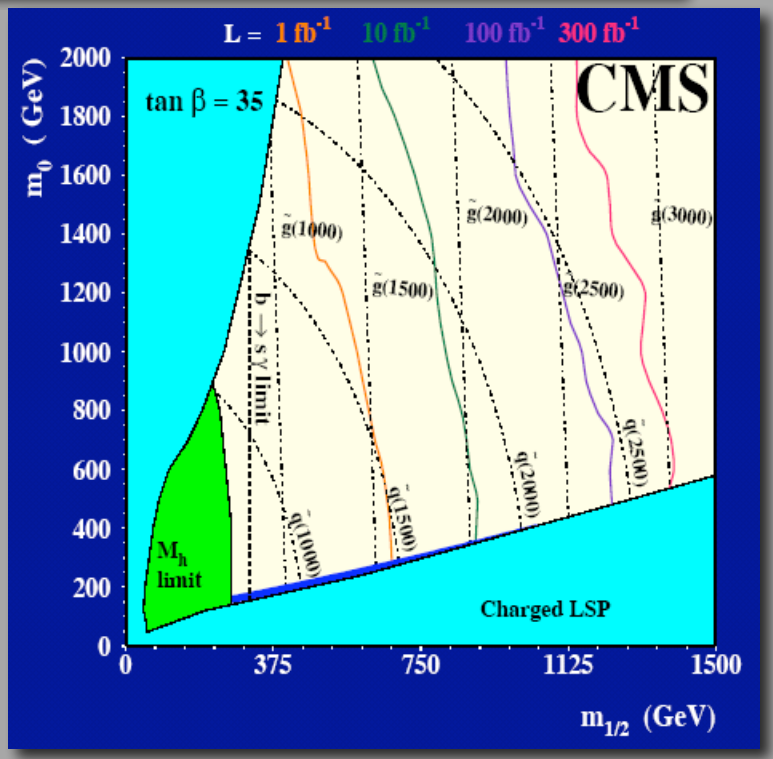
Also, very interesting results from squark/gluino and sbottom/stop searches (see Jane Nachtman's Talk)



Colliders - The LHC



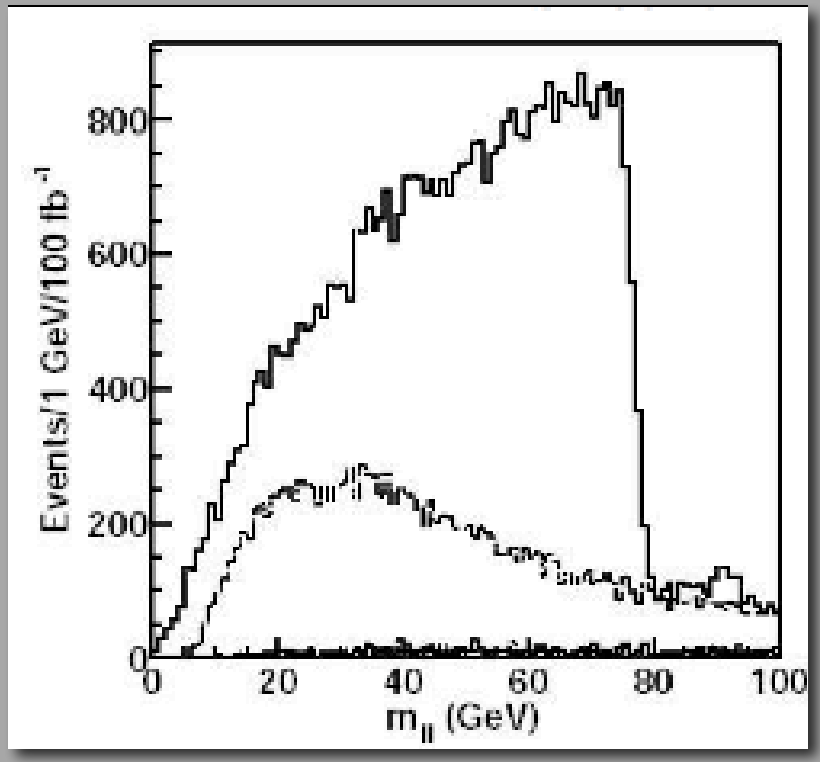




(see talks by Michael Schmitt and Xerxes Tata)

Colliders - The LHC

-The LHC is a discovery machine
-Precision measurements are much more difficult



(see talks by Michael Schmitt, Xerxes Tata and Ted Baltz)

mass/mass splitting	LCC4 value		LHC
$m(\tilde{\chi}_1^0)$	169.1	±	17.0
$m(\tilde{\chi}_2^0)$	327.1	±	49.
$m(\tilde{\chi}_2^0) - m(\tilde{\chi}_1^0)$	158.0	±	-
$m(\tilde{\chi}_3^0) - m(\tilde{\chi}_1^0)$	370.6	±	-
$m(\tilde{\chi}_1^+)$	327.5	±	-
$m(\tilde{\chi}_1^+) - m(\tilde{\chi}_1^0)$	158.4	±	-
$m(\tilde{\chi}_2^+) - m(\tilde{\chi}_1^+)$	225.8	±	-
$m(\tilde{e}_R) - m(\tilde{\chi}_1^0)$	243.2	±	-
$m(\tilde{\mu}_R) - m(\tilde{\chi}_1^0)$	243.0	±	-
$m(\tilde{\tau}_1)$	194.8	±	-
$m(\tilde{\tau}_1) - m(\tilde{\chi}_1^0)$	25.7	±	-
$m(h)$	117.31	±	0.25
$m(A)$	419.3	±	1.5 *
$\Gamma(A)$	14.8	±	-
$m(\tilde{u}_R)$, $m(\tilde{d}_R)$	944.,941.	±	94.
$m(\tilde{s}_R)$, $m(\tilde{c}_R)$	941., 944.	±	97.
$m(\tilde{u}_L)$, $m(\tilde{d}_L)$	971., 975.	±	141.
$m(\tilde{s}_L)$, $m(\tilde{c}_L)$	975., 971.	±	146.
$m(\tilde{b}_1)$	795.	±	40.
$m(\tilde{b}_2)$	862.	±	86.
$m(\tilde{t}_1)$	716.	±	(> 345)
$m(\tilde{g})$	993.	±	199.

Benchmark LCC4
Baltz, Battaglia, Peskin and Wizansky

But, our hunt does not end with discovery…

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Collider discovery of a long-lived, neutral particle

But, our hunt does not end with discovery…

Collider discovery of a long-lived, neutral particle

Direct/indirect detection needed to confirm the particle is cosmologically stable and abundant

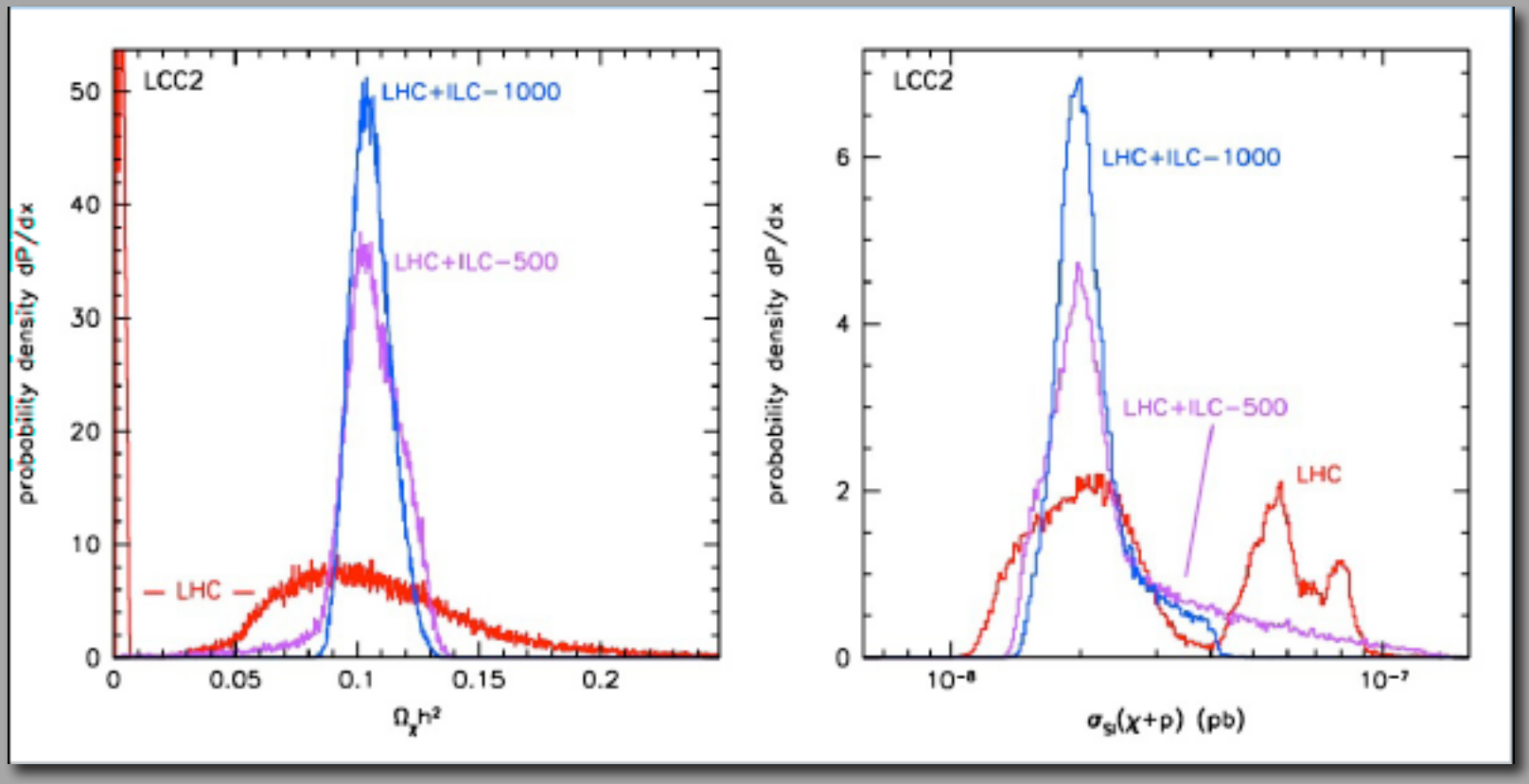
But, our hunt does not end with discovery…

Collider discovery of a long-lived, neutral particle

Direct/indirect detection needed to confirm the particle is cosmologically stable and abundant

But will the discovery stand at the supreme court of the ILC?

Confirmation At The ILC Is Essential!



(See Ted Baltz and Marco Battaglia's talks)

Confirmation At The ILC

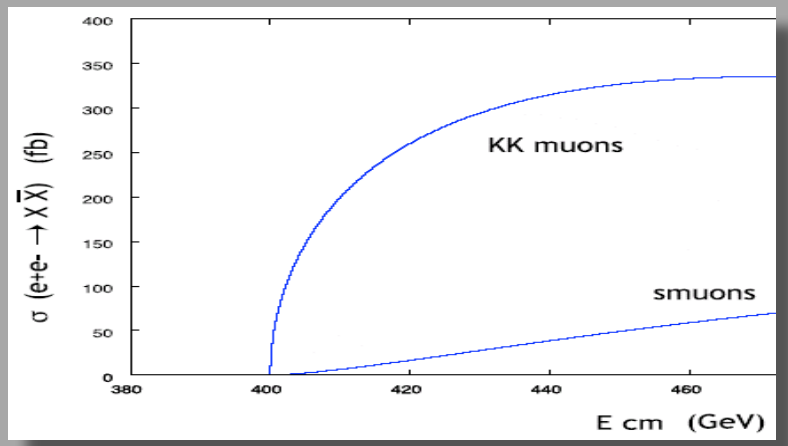
UED phenomenology

$$e^+e^- \rightarrow \mu_1^+\mu_1^- \rightarrow \mu^+\mu^-\gamma_1\gamma_1$$

closely resembles SUSY;

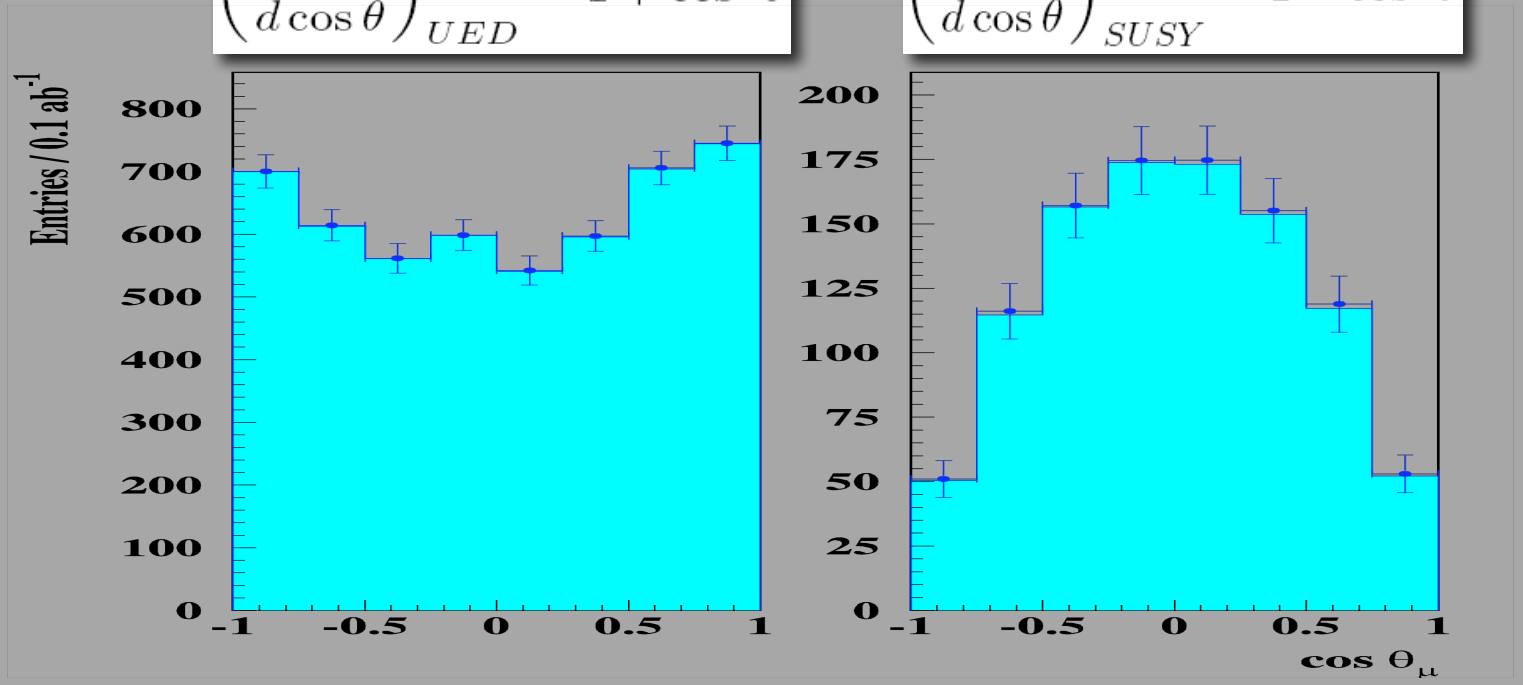
$$e^+e^- \rightarrow \tilde{\mu}^+\tilde{\mu}^- \rightarrow \mu^+\mu^-\tilde{\chi}_1^0\tilde{\chi}_1^0$$

Nature of new particles can be clearly identified by a spin analysis, based on production properties and decay angles.



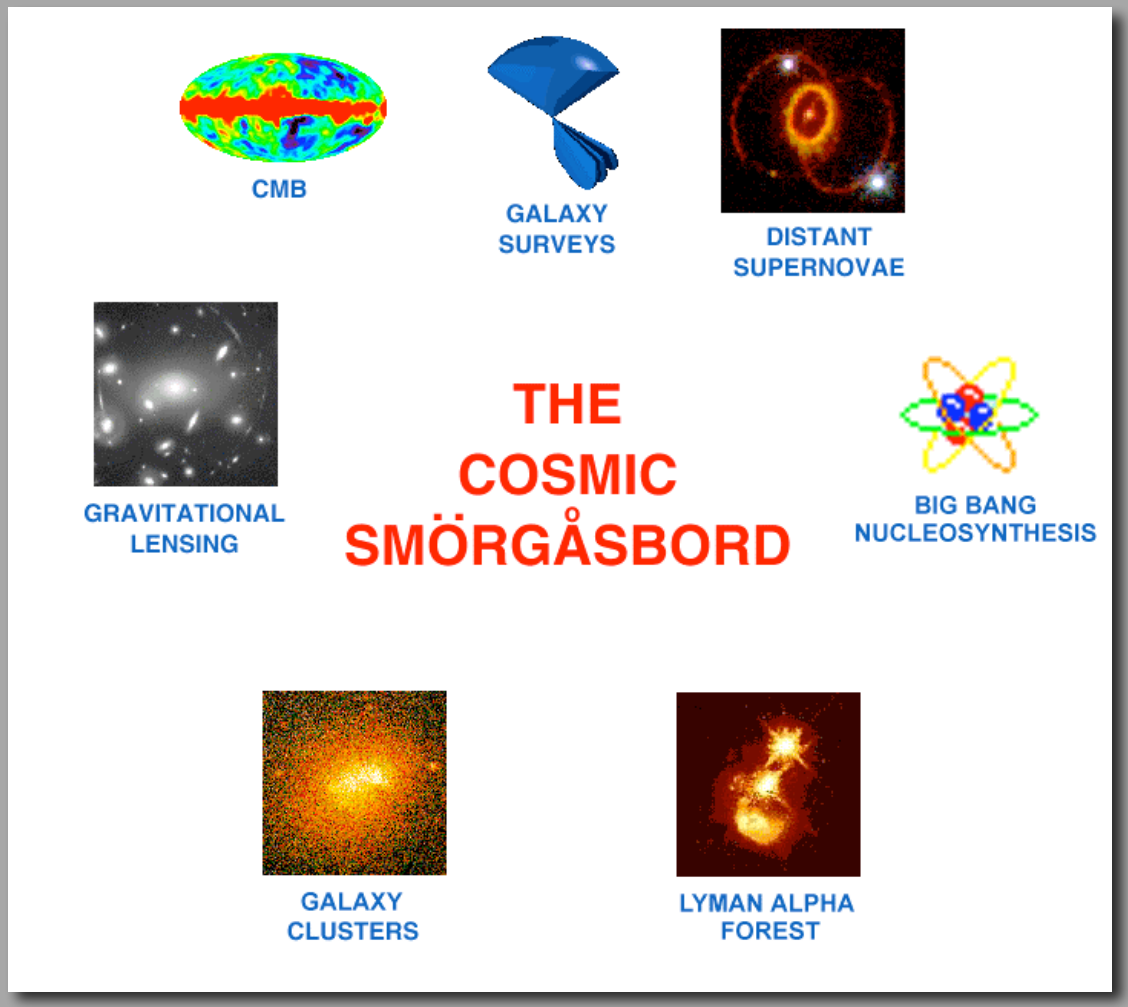
$$\left(\frac{d\sigma}{d\cos\theta}\right)_{UED} \sim 1+\cos^2\theta$$

$$\left(\frac{d\sigma}{d\cos\theta}\right)_{SUSY} \sim 1-\cos^2\theta$$



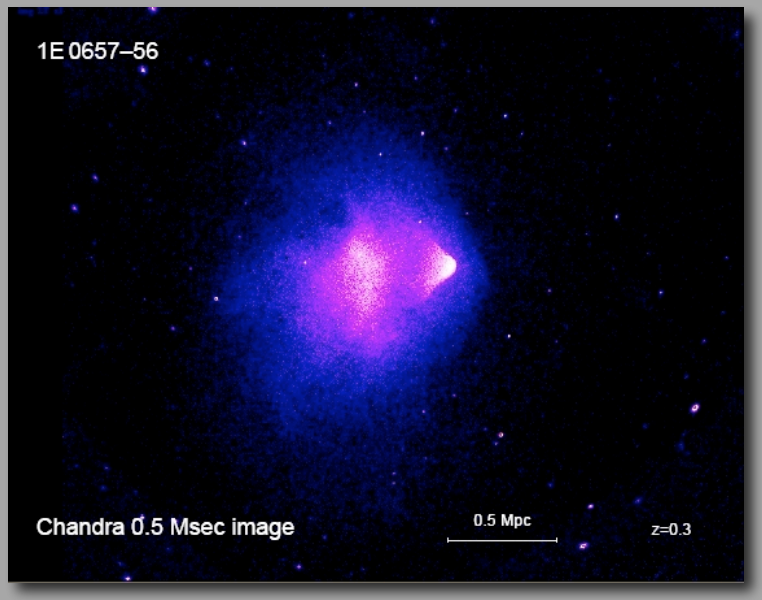
Lots of Other Interesting Stuff…

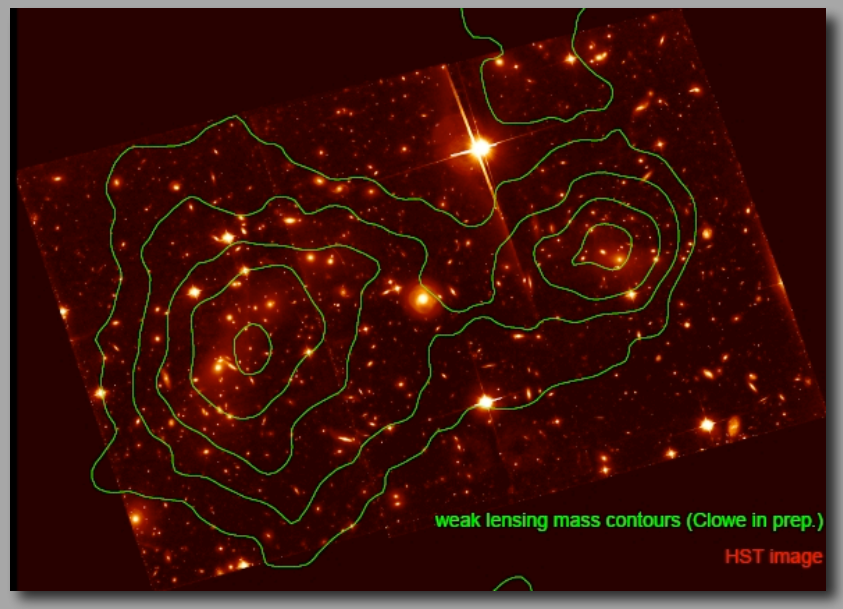
-Cosmological Evidence (Max Tegmark)



Lots of Other Interesting Stuff…

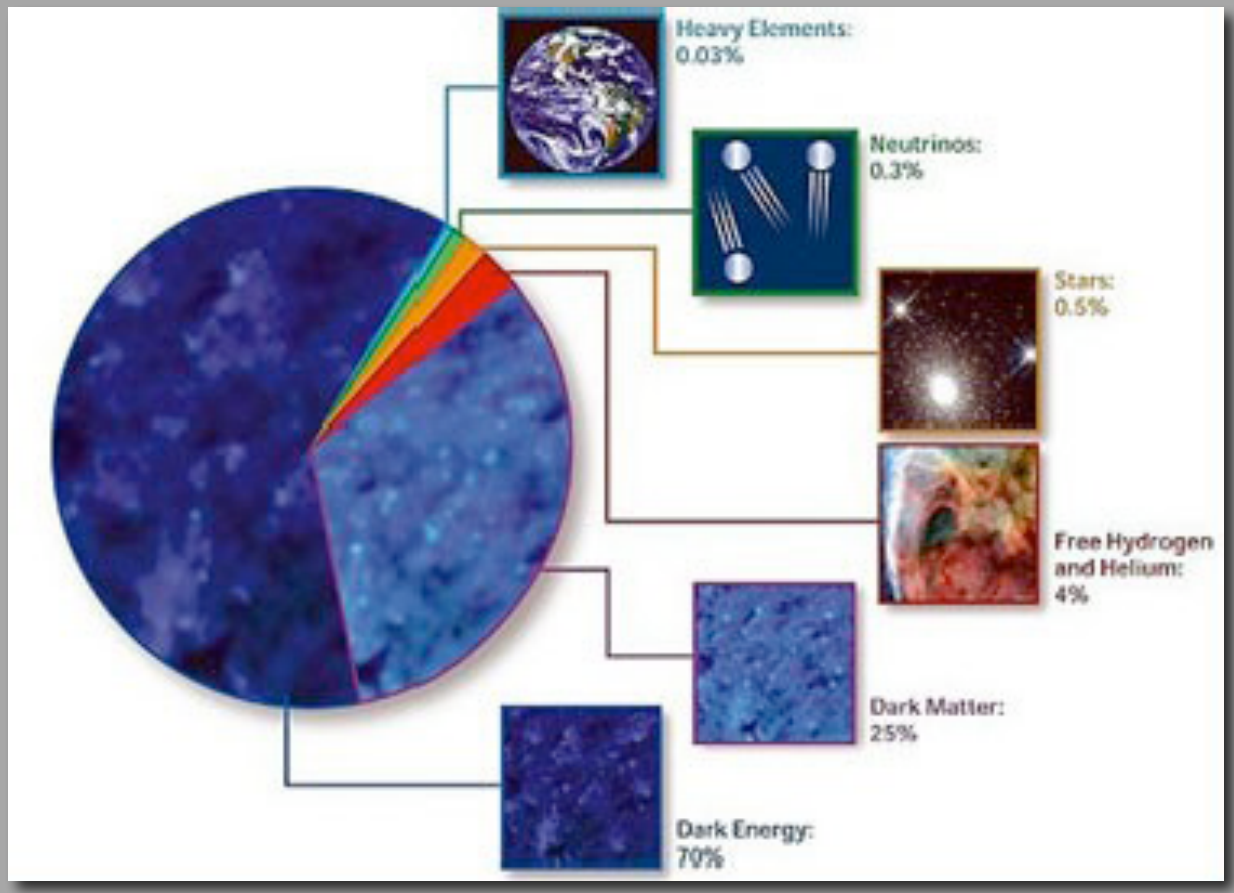
-Modifications to Gravity (Pedro Ferreira)





Lots of Other Interesting Stuff…

-Electroweak Baryogensis (Carlos Wagner)



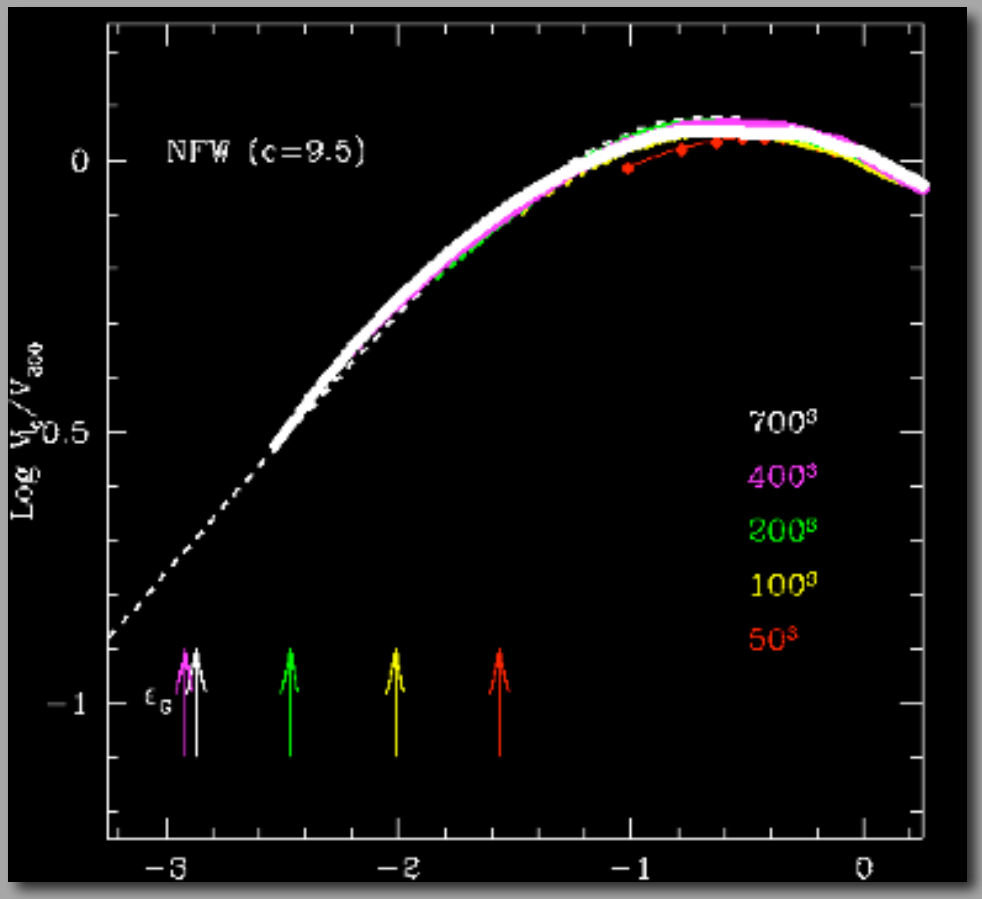
-EW Baryogensis can naturally occur in low scale SUSY

-Within the MSSM, requires a light Higgs and a light stop (and LSP)

-Models with extended Higgs sectors (nMSSM,etc) are attractive

Lots of Other Interesting Stuff…

-Simulations and Structure (Simon White)



Lots of Other Interesting Stuff…

-About 60 parallel talks…

Thanks

Organizers:

Dan Bauer
Pasquale Serpico
Andrew Sonnenschein
Marcela Carena
Karen Byrum
Mark Jackson
Fritz DeJongh
DH

Administrative Support

Judy Ripple
Cynthia Sazama
Suzanne Weber
The Fermilab conference office

Sponsors:

The Fermilab Center For Particle-Astrophysics
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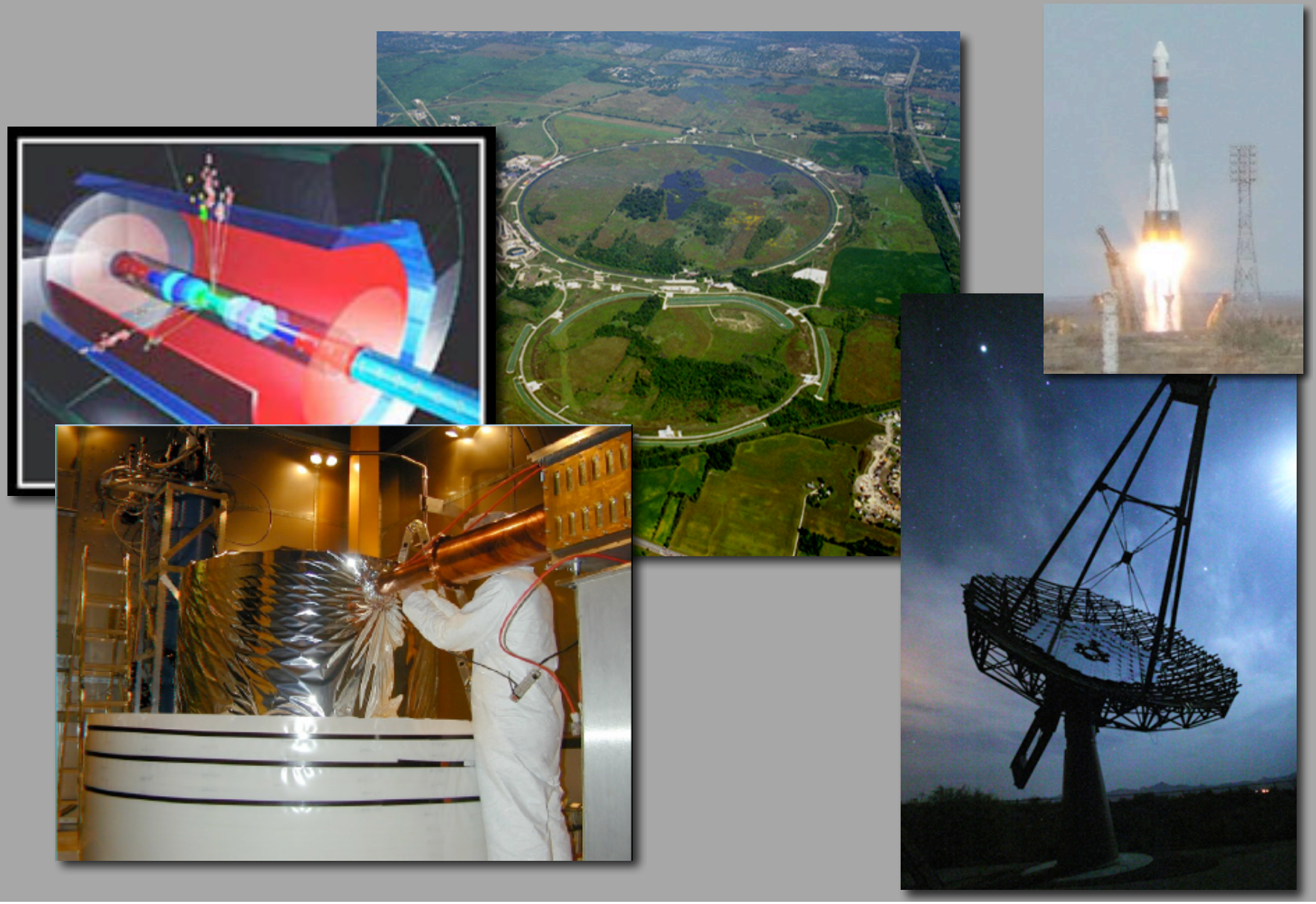
Thanks For Coming!



Let's use all of the tools we have to solve the puzzle of dark matter!